

Partnership-Centered Learning: The Case For Pedagogic Balance In Technology Education.

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Introduction

In many parts of the world, technology education is a subject area in transition (Eggleston, 1992; Fritz, 1996; Lauda, 1988; Wicklein, 1993). This has, and continues to be the case in countries such as America (Newberry, 2001; Sanders, 2001), the United Kingdom (McCormick, 1997) and Australia (Fritz, 1996). In each of these aforementioned countries, various modifications to standards statements (ITEA 2000), curriculum documents (QCA, 1999), and technology syllabi (QSA, 2002a; QSCC, 2000) are currently being drafted and redrafted. Curriculum reform in technology education seeks to modify the workshop-based industrial arts tendency to focus on industrial hand and machine skills (Young-Hawkins & Mouzes, 1991) to a focus more concerned with critical and creative higher-order thinking skills (Lee, 1996). These types of technology subjects are designed to respond to societal changes, such as those evident in many of the world's current post-industrial technological societies (Lauda, 1988).

The traditional pedagogy of workshop-type industrial arts subjects was, and in many cases still is, "show and follow" (Fritz, 1996, p.212), and it has been used to good effect in the building of student competencies, particularly industrial skills. However, technology education's evolution is transforming the subject from one that requires students to imitate teacher-prescribed industrial hand and machine skills to one that is argued to be unique in the school curriculum (Williams, 2000). Technology education is evolving to become a subject that is concerned with an individual student's ability to solve real world problems by integrating specifically relevant knowledge of materials, technological processes, and systems (Eggleston, 1992; QCA, 1999; QSA, 2002b). Technology education students are encouraged to reflect on and modify their thinking through their involvement with some form of technological design-type process. For example, the National Curriculum for Design and Technology in the United Kingdom (QCA, 1999) places importance on each student's ability to combine both the practical (hand skills) and theoretical

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(thinking skills) during their individual and group technological problem-solving activities by stating that students are expected to:

... learn to think and intervene creatively to improve quality of life. The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so, they reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology, all pupils can become discriminating and informed users of products, and become innovators. (p.15)

By endorsing documents such as the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000), the International Technology Education Association (ITEA) emphasizes the requirement for students to become technologically literate. The focus through this and other documents is to define a set of curricula standards for use in all American states that promotes the development of technological literacy in students. One of the principles that guided the formation of these standards is the requirement for students to participate in "active and experiential learning" (ITEA, 2000, p.3). The document, *Technology for all Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996) provides further support for recognition of the importance of combining both thinking and practical activities during a technological design process. This approach to curriculum formulation is argued to be significant in terms of developing the technological literacy of students (ITEA, 1996; Lewis & Gagel, 1992). The Technology for all Americans document states that:

The technological design process involves the application of knowledge to new situations or goals, resulting in the development of new knowledge. Technological design requires an understanding of the use of resources and engages a variety of mental strategies, such as problem solving, visual imagery, and reasoning. Developing these mental abilities and strategies so that they can be applied to problems is a significant aspect of technological literacy. These abilities can be developed in students through experiences in designing, modeling, testing, troubleshooting, observing, analyzing, and investigating." (p.18)

The recent changes in technology syllabi (Australia), curriculum documents (United Kingdom), and standards statements (America) are requiring that teachers and students acknowledge and embrace a restructuring of the balance of instructional power. The technology learning environment is currently undergoing a transformation from one that incorporates predominately teacher-centered teaching and learning strategies to one more oriented to student-

centered learning. For example, the current *Industrial Technology and Design Subject Area Syllabus* (IT&D) in Queensland, Australia (QSA, 2002b) has been formulated in response to the *Technology Key Learning Area Syllabus* (QSCC, 2000) and emphasizes the requirement for teaching strategies that facilitate particular types of student- (learner) centered learning activities. The IT&D syllabus document states that:

A learner centred approach provides opportunities for students to practise critical and creative thinking, problem solving and decision making. These involve the use of knowledge, practices and dispositions such as recall, application, analysis, synthesis, prediction and evaluation, all of which contribute to the development and enhancement of conceptual understandings. A learner-centred approach also encourages students to reflect on and monitor their thinking as they make decisions and take action. (p.13)

For both teachers and students in technology education, the traditional norms or expectations (Talbert & McLaughlin, 1993) associated with teaching and learning are now changing. Students are expected to become more autonomous toward their learning, and teachers are expected to facilitate this type of student learning activity. However, an apparent paradox exists within the subject's transition, and this may serve to hinder the change of focus from teacher- to student-centered learning. The paradox for both teachers and students is the necessity for teachers to demonstrate for students the safe and proper use of a range of hand, machine, and computer skills, as well as model for students a range of technological problem-solving skills. These types of skills provide students with the opportunity and facility to fulfill the various requirements of the technological design process, regardless of learning environment type. For example, students participating in CAD lessons initially require some form of teacher exposition of the necessary skills to facilitate their competent use of the CAD program. Once known and understood, this knowledge serves to support student-initiated design and problem-solving activities within the same CAD learning environment. Similarly, more traditional workshop environments support students' procedural abilities, in terms of hand and machine skills, until students are adept at applying these previously acquired skills during their technological design activities.

Therefore, technology education as a subject area has not necessarily devalued the traditional hand and machine skills of workshop industrial arts-type subjects, but rather it has revalued these skills in conjunction with cognitive problem-solving skills to have particular significance within the technological design process. For both teachers and students of technology education, the prescribed need to continue with teaching strategies that are associated with the norms of industrial arts-type subjects, creates tensions (Engestrom, 1993, 1999). These tensions occur as a result of changes in technology syllabus focus (i.e., from industrial skills to thinking skills) and the subsequent pressures these

changes impose upon teachers and students with regard to the redistribution of learner and teacher pedagogic control. It is not suggested that the skills-based curriculum constructed from the industrial arts syllabi of the recent past totally disassociated students from using thinking skills. However, it is argued that traditional industrial arts programs focused more on skills-based instruction, and that the current expectation is for technology education to focus instead on a student's technological problem-solving abilities using cognitive, hand, machine, and other skills provided by teachers or acquired by students directly for this purpose.

The need to develop both hand skills and problem-solving abilities requires technology teachers to walk a pedagogic tightrope. On the one hand, teachers need to develop in students a degree of manual dexterity in the use of materials and processes, using both hand and machine tools. These skills have been traditionally taught by a teacher-centered "show and follow" strategy, the most familiar and comfortable strategy for industrial arts teachers (Fritz, 1996). On the other hand, technology teachers need to facilitate with students the autonomous development of their own cognitive and metacognitive strategies when solving technological problems. These are created through their involvement with the technological design process (Deluca, 1992). It is argued that these types of learning environments require a teacher-facilitated student-centered pedagogy (Deluca, 1992; Johnson, 1996).

It is the balance teachers create between teacher-centered and student-centered pedagogies within their technology classrooms that influences how students perceive the learning situation, and ultimately how and what they learn in technology education (Deluca, 1992; McCormick, Murphy & Hennessy, 1994). Bell (2000) addresses the issue of balance between student-managed (centered) learning activities and teacher-directed (centered) learning activities by stating that:

Learning is a dynamic process, and the location of the balance between teacher-directed and student-managed activities can likewise be expected to be always dynamic. The emergence of personal ownership of learning is the hallmark of a true student, and shifting the balance to foster the growth of such independence is perhaps the key challenge within teaching at this level. It is a challenge which must be approached sensitively as teachers recognise and respond to the needs of the individual. While the balance between teacher-directed and student-managed learning may not be critical, the direction in which it is moving for each individual certainly is. Learning partnerships develop as the strategies intermingle and the distinction between formal roles becomes blurred. In such partnership-centred learning the balance is found (p.149).

This paper argues that the concept of partnership-centered learning (Bell, 2000) provides a more optimal teaching and learning strategy for providing the required dynamic balance between teacher exposition and student autonomy in technology classrooms. That is, as the technology learning situation dictates, teachers must adjust their teaching strategies from learner- to teacher-centered

(e.g., from student autonomy to teacher exposition). It is the continually adjusting learning partnership created between teachers and students that helps to facilitate the desired higher-order thinking outcomes of students (e.g., critical and creative thinking, problem solving, and decision making), which are said to be encouraged by the technological design process (Williams, 2000). To support this argument, this paper presents the results of a study conducted by this author as an honors thesis requirement. It examined the cognitive activities of year nine and ten technology students from ages 13 to 15 years in technology education classrooms, and further details can be found by using the reference to Walmsley (2001) in this paper.

Technology Education and Higher-Order Thinking

In acknowledgement of the lack of empirical research into the cognitive activities of technology students (Johnson, 1997) and in "particular of what teachers and students actually do in classrooms" (McCormick, 1996, p.72), a study of 480 year nine and ten students in Queensland state and independent high schools was initiated to examine technology education classrooms. This study focused on student perceptions of their own learning activities. Aspects of cognitive theory in the form of Cognitive Holding Power (Stevenson, 1998; Stevenson & Evans, 1994) were used to examine the relationship between students' use of procedural knowledge and the task environment in various technology classrooms. The Cognitive Holding Power (CHP) concept is defined as the press exerted by an educational learning environment, which causes students to utilize certain levels of procedural knowledge (see Stevenson & Evans for details). The press refers to the learning environments' influence on positive or negative goal attainment and is activated by the types of tasks with which students engage during their learning activities (Stevenson & Evans). Two factors that are interpreted as being most influential in terms of CHP are the teacher and the subject matter (Stevenson).

The CHP concept is significant because it interprets a learning environment's influence on students' use of different levels of procedural knowledge. Stevenson and McKavanagh (1992) interpret procedural knowledge in terms of hierarchies or orders. First order procedural knowledge is defined as knowledge of how to perform specific skills, much the same as the industrial skills that students in traditional industrial arts-type technology learning environments would be expected to perform. Second order procedural knowledge is defined as knowledge of how to apply problem-solving skills that assist with the application of previously acquired first order skills and conceptual knowledge to new and unusual situations. Second order procedural knowledge would be expected to be evident during students' technological problem-solving activities (higher-order thinking) in design process-based technology education classrooms (Garcia, 1994). Third order procedural knowledge is defined as knowledge whereby judgments can be made as to the appropriateness of all other levels of knowledge in specific circumstances. Of particular significance for technology education is the ability of the CHP

construct to differentiate between learning environments that press for either first order procedural knowledge, learning environments that have first order cognitive holding power (FOCHP); or learning environments that press for second order procedural knowledge, learning environments that have second order cognitive holding power (SOCHP) (Stevenson, 1998).

An instrument has been developed, validated, and found reliable (Stevenson, 1998; Stevenson & Evans, 1994) in assessing learning environments relative to students' perceptions of the press for different levels of procedural knowledge. The Cognitive Holding Power Questionnaire (CHPQ) requires students to respond to 30 questions that relate to the amount of control students perceive they or their teachers have over their learning activities. Each question in the CHPQ requires students to respond to a five-tiered Likert scale, ranging from *almost never* to *very often*. Questions such as, "I ask questions to check my results" and "I try out new ideas" require responses that indicate the students' perception of a learning environment that presses for student control (SOCHP). Questions such as, "I copy what the teacher does" and "I feel I have to work exactly as I am shown" require responses that indicate the students' perception of a learning environment that presses for teacher control (FOCHP).

The study examined independent and public high schools in the southeast corner of Queensland, Australia. The 480 students in the nine high schools studied provided a statistically significant number of responses to the CHP questionnaire. These schools were selected because they each had previously implemented the developing years 1 to 10 technology syllabus (QSCC, 2000) on a trial basis during the 2000 school year. This provided each school with prior knowledge of the changing focus of the technology curriculum. On the basis of this prior knowledge, each school's Head of Technology Education Department (HOD) rated his own department's teaching orientation as being either design-based, manual arts-based, or a combination of the two. In many Queensland high schools, the subject title "manual arts education" is used to define an industry-related subject area that in other parts of the world would be best recognized and defined as "industrial arts education." The rating process was conducted in consultation with the researcher and therefore enabled good consistency of description among schools as to the characteristics that constituted a design, industrial arts, or a combined technology learning environment. Fundamental to how HODs described their school's approach, was the extent to which students contributed to their own learning within a design process curriculum. These teachers (HODs), by their own volition, saw the difference between industrial arts and technology education as being one of student-centered learning (design/tech ed.) versus teacher-centered learning (industrial arts).

The study required each year 9 and 10 student to respond to a modified version of the Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1998) after first providing parental or guardian consent. The modification of the CHPQ was restricted to the changing of the questionnaire's title to the Technology Environment Response Form (TERF).

Table 1

Distribution of Students Among Teaching Orientations by Grade Level and Gender

Teaching Orientation	Male			Female			Grand Total
	Yr. 9	Yr. 10	Total	Yr. 9	Yr. 10	Total	
Design Based	33	51	84	54	23	77	161
Industrial Arts Based	48	97	145	15	11	26	171
Combination Ind. Arts & Design	77	49	126	14	8	22	148
Total	158	197	355	83	42	125	480

The student responses to the modified version of the CHPQ were tabulated and recorded using the Statistical Package for the Social Sciences. Means and standard deviations of student responses regarding FOCHP and SOCHP were analyzed with reference to school teaching orientation, year level, and gender. Analysis of variance *F*-test (ANOVA), Univariate analysis of variance using Type III sum of squares, and Scheffe *post hoc* comparisons were conducted to determine the significance of between and within category responses (Bryman & Cramer, 1997; Field, 2000). In addition, a principal component analysis with Varimax rotation, and Cronbach's α reliability scores (Bryman & Cramer; Field) for the tested variables was used to interpret the reliability of the scales FOCHP and SOCHP, and the validity of the CHPQ construct. The results of this later analysis upheld the construct validity of the CHPQ and the reliability of the scales FOCHP and SOCHP. Table 1 displays the response numbers of students per variable.

Table 2

Mean Results for Cognitive Holding Power by Teaching Orientation

Teaching Orientation	FOCHP		SOCHP		N
	M	SD	M	SD	
Design Based	3.08	0.56	3.12	0.52	161
Combination Design/ Industrial Arts Based	3.09	0.54	2.96	0.52	148
Industrial Arts Based	3.07	0.68	2.92	0.58	171
Total	3.08	0.60	3.00	0.55	480

The study found that students interpreted an increased press for SOCHP relative to the extent of design-based teaching orientation in their technology learning environment. That is, technology subjects with a design-oriented teaching strategy exhibited a superior mean result for SOCHP to that of both industrial arts and the combined categories. However, the mean results for FOCHP were consistent across all three teaching orientations. Table 2 displays

the mean results and standard deviations for FOCHP and SOCHP across teaching orientations.

Further investigations of these data using a one-way analysis of variance (ANOVA) (Field, 2000) for the effect of technology subject teaching orientation on CHP, found the relationship with SOCHP to be significant ($F = 6.322$; $p = 0.002$) but unsubstantial (adjusted R squared = 0.022). Further analysis (ANOVA) of the SOCHP means between the design-based and industrial arts-based learning environments only, indicates that the variation is more significant ($F = 11.093$; $p = 0.001$). However, the effect of teaching orientation on SOCHP between design- and industrial arts-based learning environments only, accounts for just 3% of the variance (adjusted R -squared = 0.03). The relationship between FOCHP and technology subject teaching orientation was found not to be significant ($F = 0.025$; $p = 0.98$). A Scheffe *post hoc* test of comparison between teaching orientations and SOCHP revealed that design-based learning environments were significantly superior to both industrial arts-based and combined design- and industrial arts-based environments ($p = 0.003$ and $p = 0.035$ respectively). However, no significant difference was discovered between industrial arts and the combined categories ($p = 0.79$).

Table 3
CHP by Gender, Level, and Teaching Orientation

Teaching Orientation	Gender	Year Level	FOCHP <i>M (SD)</i>	SOCHP <i>M (SD)</i>
Design Based	Male	9	3.05 (.49)	3.11 (.58)
		10	3.08 (.58)	3.04 (.55)
	Female	9	3.11 (.62)	3.22 (.48)
		10	3.04 (.51)	3.11 (.46)
Combined Design & Industrial Arts Based	Male	9	3.10 (.57)	2.95 (.53)
		10	3.04 (.55)	2.95 (.50)
	Female	9	3.26 (.40)	3.11 (.56)
		10	2.88 (.32)	2.88 (.51)
Industrial Arts Based	Male	9	3.30 (.47)	2.89 (.69)
		10	2.95 (.64)	2.94 (.63)
	Female	9	3.20 (.68)	2.93 (.67)
		10	2.94 (.58)	2.92 (.51)
Total Results	Male	9	3.15 (.60)	2.97 (.52)
		10	3.01 (.61)	2.97 (.58)
	Female	9	3.15 (.61)	3.15 (.54)
		10	2.98 (.50)	3.02 (.48)

Table 3 displays the mean results and standard deviations for gender across year levels and technology subject teaching orientation. Results for SOCHP and gender and year level in design-based learning environments reinforce the

previous mean results found for SOCHP and design-based teaching orientation. That is, students in design-based technology learning environments relative to age and gender perceive a higher press for SOCHP than do other forms of teaching orientation. An analysis of variance for SOCHP between genders found a significant ($F = 5.80$; $p = 0.016$), but unsubstantial relationship (Adjusted R -squared = 0.010). The study provided no support for either gender or year level, e.g., classroom observations of teacher and student interactions, and as a result, no further data analysis was conducted of the significance of the mean results for gender and year level. However, the mean results for both gender and year level further support the overall significance of the results for subject teaching orientation, the construct validity of the CHPQ, and the reliability of the two scales of FOCHP and SOCHP.

Discussion

The results of this study of the cognitive activities of technology students in different types of technology learning environments indicate that students do experience an increased and significant, yet unsubstantial, press for second-order procedures (higher-order thinking, e.g., technological problem-solving) in design-based technology classrooms. Results also indicate that students are equally pressed for first-order procedures (skill development) throughout all forms of the technology learning environment, regardless of that environment's design component. This empirical research evidence regarding students' perceptions of their own learning activities provides support for the argument that design-based technology teachers are currently grappling with the need for some form of balance between teacher support (FOCHP) and student autonomy (SOCHP). It appears that students do perceive significant control over their learning in design-based classrooms. However, the study found that the extent of this student control was not substantial. The norms of current technology curriculum practice, which are rooted in teacher demonstration and exposition, continue to exist as a possible result of technology education's craft traditions (McCormick & Davidson, 1996). These norms may be causing design-based teachers to balance their instruction in the direction of teacher control (Wiske, 1994).

These research results suggest that teachers do recognize the need to mix pedagogies (design: SOCHP and industrial arts: FOCHP) in order to balance their curriculum. However, the changing emphasis within all forms of technology curriculum documentation from industrial skill development to cognitive skill development, dictates that the balance between teacher-centered and student-centered learning should now favor the direction of the latter. It appears that design-based technology education teachers are currently adopting a more learner-centered approach to curriculum delivery, but are doing so while still maintaining a certain level of student perceivable control over what, how, and when students learn. These technology teachers may be placing more importance on the making (doing) phase of the design process in preference to (but not excluding) the thinking and planning stages (McCormick & Davidson,

1996). Now in the subject's evolving history, it appears that students perceive the balance between teaching strategies as being only marginally weighted toward the more student-centered strategies of the design process. The lecture and demonstration strategies of industrial arts education still appear to have considerable influence concerning how students perceive control over their learning. Hennessy, McCormick and Murphy (1993) consider that students superficially and mechanically follow a prescribed and sequential series of analyzing and monitoring tasks as a result of not only "lack of competence, but from the ways in which we [they] believe activity is structured in schools" (p. 83).

The tendency of technology students to follow, as argued by Hennessy, McCormick, and Murphy, is perhaps unknowingly perpetuated by the students themselves. For example, Grossman and Stodolsky (1994) argue that students unwittingly pressure teachers into the use of teaching strategies that match their preferred method of learning and that, "...students exert pressure on teachers to teach in certain ways; their perceptions of the subject may contribute to these expectations" (p.207). The historical roots of technology education in industrial arts education may be one factor that skews students' expectations toward learning in design-based technology classrooms in the direction of the traditional lecture and demonstration, teacher-centered approach. The possible consequence of students' expecting to learn in design-based classrooms through more traditional teacher-centered methods might be that teachers choose to teach to student expectations. Teachers may feel that they are violating the currently accepted norms (lecture and demonstration) of learning and teaching in technology education by adopting more student-centered, problem-solving type pedagogies.

In a study of creativity development and the design approach to learning in technology education, Davies (2000) found that the perceptions teachers and students hold of each other have an effect on creative endeavors and thus on student higher-order thinking. It is argued that students do not feel that teachers model the processes involved in creative activity and are therefore not considered competent in this area. Davies also argued that teachers underestimate student abilities and do not generally encourage students to take risks, which ultimately reduces the potential learning experiences of students.

Deluca (1992) studied the various teaching strategies used by exemplary technology teachers to encourage students during their technological problem-solving activities. Deluca found that strategies argued to be associated with higher-order thinking (SOCHP), such as panel discussion, role play, case study, seminar, and contract were used less often than strategies associated with lower-order thinking (FOCHP), such as teacher lecture and demonstration. Deluca therefore argued that teachers see the need to provide students with the basic conceptual and procedural information before allowing students the freedom to move on to more autonomous forms of learning. In other words, instructional methods change from teacher-centered to student-centered learning, as the teacher deems appropriate. However, one may argue that technology teachers

who adopt this type of instructional tactic are predisposing students to the safety inherent in the instructional norms of industrial arts, rather than to the potential risks (by teachers and students) associated with the more independent types of student learning activity found potentially within the technological design process (Davies, 1999). Davies advocates a learning partnership between teacher and student by stating that:

If the teacher chooses to make decisions on behalf of the student, they might not necessarily be acting in the best interests of the student overall. If teachers and learners share the risks associated with the learning process, better quality learning is likely to be achieved. (p. 107)

Conclusion

Curriculum reform for technology education teachers requires that they create with students a learning partnership, and that this partnership should promote learner autonomy. If students are to perceive a substantial level of control over their own learning (as required by technology curriculum documents), this partnership must favor student-initiated learning activity. The inherent value of the concept of partnership-centered learning (Bell, 2000) for technology education lies not so much in its yearning for pedagogic balance, but in the idea that traditional teaching and learning roles become blurred and that in the process, the direction of change (i.e., from teacher-centered to student-centered) becomes of more importance for the individual student than the overall extent of any change.

The Cognitive Holding Power Questionnaire (Stevenson, 1998) enables both teachers and researchers to measure how students perceive their technology classrooms in terms of either teacher- or student-controlled learning activities. Therefore, by measuring students' perceptions incrementally over set periods, an indication may be gained as to how students perceive the trend of pedagogic change in technology education rather than focusing only on the extent of that change. Lewis (1999) agreed with the need for classroom research that examines the relationship between learning outcomes and instructional reform in technology education. He stated that:

...perhaps another way to approach this question [pedagogic change] is incrementally; that is, the researcher works *forward* from practice towards the ideal. Every increment of change along the way counts. Thus, there is need for subtle methods to measure change. Small changes might be more typical in practice, and it would be a mistake for the field to overlook them. (p.48)

This author's study of the cognitive comparison of learning in various forms of technology classrooms along the pedagogic continuum (i.e., from teacher-centered to student-centered learning) provides a starting point for measuring the cognitive effects of instructional reform in technology education. The accumulation of knowledge from empirical research conducted on actual technology classroom learning activities and student perceptions of pedagogic

control may influence technology teachers to seek ways of supporting students' increased use of higher-order thinking processes. Technology teachers may achieve an increase in students' use of higher-order thinking by subtly redefining the optimal balance between teacher and student-centered learning in their own technology classrooms. Perhaps the optimal pedagogic balance in technology education is achievable using teaching strategies that blur traditional teaching and learning roles. Teaching strategies of this type may ultimately facilitate the formation of teacher and student learning partnerships in technology education.

References

- Bell, C. R. (2000). *Finding the balance: Comparing the effectiveness of student-managed and teacher-directed learning in science classes*. Master's thesis, Curtin University of Technology. Retrieved June 19, 2000, from <http://jennifer.lis.curtin.edu.au/thesis/available/adt-WCU20020429.100506/>
- Bryman, A., & Cramer D. (1997). *Quantitative data analysis with SPSS for Windows*. London & New York: Routledge.
- Davies, T. (1999). Taking risks as a feature of creativity in the teaching and learning of design and technology. *The Journal of Design and Technology Education*, 4(2), 101-108.
- Davies, T. (2000). Confidence! Its role in the creative teaching and learning of design and technology. *Journal of Technology Education*, 12(1), 18-31.
- Deluca, W. V. (1992). Survey of technology education problem-solving activities. *The Technology Teacher*, 51(5), 26-30.
- Eggleston, J. (1992). *Teaching design and technology*. Buckingham, England: Open University Press.
- Engestrom, Y. (1993). Developmental studies of work as a testbench of activity theory: The case of primary care medical practice. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp.64-103). Cambridge University Press.
- Engestrom, Y. (1999). *Expansive learning at work: Toward an activity-theoretical reconceptualization*. Paper presented at the 7th Annual International Conference on Post-Compulsory Education and Training. Changing Practice Through Research: Changing Research Through Practice. December 6-8, 1999. Centre for Learning and Work Research, School of Vocational, Technology and Arts Education, Faculty of Education, Griffith University, Brisbane.
- Field, A. (2000). *Discovering statistics using SPSS for Windows*. Sage Publications, Inc.
- Fritz, A. (1996). Reflective practice: Enhancing the outcomes of technology learning experiences. *The Journal of Design and Technology Education*, 1(3), 212-217.
- Garcia, J. R. (1994). *Use of technology in developing problem solving/critical thinking skills*. (ERIC Document Reproduction Service No. ED 369 944).

- Grossman, P. L. & Stodolsky, S. S. (1994). Considerations of content and the circumstances of secondary school teaching. In L. Darling-Hammond (Ed.), *Review of research in education*, 20 (pp.179-221). Washington, DC: American Educational Research Association.
- Hennessy, S., McCormick, R., & Murphy, P. (1993). The myth of general problem-solving capability: Design and technology as an example. *The Curriculum Journal*, 4(1), 73-89.
- ITEA, International Technology Education Association, (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Retrieved August 13, 2002, from <http://www.itea.org/TAA/PDF/Taa.RandS.pdf>
- ITEA, International Technology Education Association, (2000). *Standards for technological literacy: Content for the study of technology, executive summary*. Retrieved August 13, 2002, from <http://www.itea.org/TAA/PDF/Execsum.pdf>
- Johnson, S. D. (1996). Technology education as the focus of research. *The Technology Teacher*, 55(8), 47-49.
- Johnson, S.D. (1997). Learning technological concepts and developing intellectual skills. *International Journal of Technology and Design Education*, 7, 161-180.
- Lauda, D. P. (1988). Technology education. In W. H. Kemp & A. E. Schwaller (Eds.), *Instructional strategies for technology education* (pp. 3-15). Glencoe Publishing Company.
- Lee, S. (1996). *Problem-solving as intent and content of technology education*. Paper presented at the International Technology Education Association 58th Annual Conference in Phoenix, Arizona, March 31-April 2, 1996. (ERIC Document Reproduction Service No. ED 391 959).
- Lewis, T. (1999). Research in technology education: Some areas of need. *Journal of Technology Education*, 10(2), 41-56.
- Lewis, T., & Gagel, C. (1992). Technological literacy: A critical analysis. *Journal of Curriculum Studies*, 24(2), 117-138.
- McCormick, R. (1996). Instructional methodology. In J. Williams & A. Williams (Eds.), *Technology education for teachers* (pp. 63-92). Macmillan Education Australia Pty. Ltd.
- McCormick, R., & Davidson, M. (1996). Problem solving and the tyranny of product outcomes. *The Journal of Design and Technology Education*, 1(3), 230-241.
- McCormick, R., Murphy, P., & Hennessy, S. (1994). Problem-solving processes in technology education: A pilot study. *International Journal of Technology and Design Education*, 4, 5-34.
- Newberry, P. B. (2001). Technology education in the U.S.: A status report. *Technology Teacher*, 61(1), 8-12.
- QCA, Qualifications and Curriculum Authority. (1999). *Design and technology: The national curriculum for England*. Retrieved August 13, 2002, from <http://www.nc.uk.net/download/bDT.pdf>

- QSA/Queensland Studies Authority. (2002a). *Consultative network*. Retrieved August 2, 2002, from <http://www.qsa.qld.edu.au/yrs1-10/kla/technology/consultative.network.html>
- QSA/Queensland Studies Authority. (2002b). *Industrial technology and design subject area syllabus*. Retrieved August 2, 2002, from <http://www.qsa.qld.edu.au/yrs1-10/kla/otherstudies/sas/itd.ed.pdf>
- QSCC/Queensland School Curriculum Council. (2000). *The technology years 1 to 10 syllabus-in-development pilot draft terms 1 to 3, 2000*. Retrieved September 15, 2000, from <http://qscq.qld.edu.au/kla/technology/pdf/pilotsyllabus.pdf>
- Sanders, M. (2001). New paradigm or old wine? The status of technology education practice in the United States. *Journal of Technology Education*, 12(2), 35-55.
- Stevenson, J. C. (1998). Performance of the cognitive holding power questionnaire in schools. *Learning and Instruction*, 8(5), 393-410.
- Stevenson, J. C., & Evans, G. T. (1994). Conceptualization and measurement of cognitive holding power. *Journal of Educational Measurement*, 31(2), 161-181.
- Stevenson, J. C., & McKavanagh, C. W. (1992). Skill formation for the workplace. In M. Poole (Ed.), *Education and work*. Australian Council for Educational Research Ltd. (pp.72-90).
- Talbert, J. E. & McLaughlin, M. W. (1993). Understanding teaching in context. In D. K.Cohen, M. W.McLaughlin, & J. E. Talbert (Eds.), *Teaching for understanding: Challenges for policy and practice* (pp. 167-206). San Francisco: Jossey-Bass.
- Walmsley, B. D. (2001). *Technology education learning environments and higher-order thinking*. Honours Thesis. Griffith University, Brisbane, Queensland, Australia.
- Wicklein, R. C. (1993). Developing goals and objectives for a process-based technology education curriculum. *Journal of Industrial Teacher Education*, 30(3), 66-80.
- Williams, J. (2000). Design: The only methodology of technology? *Journal of Technology Education*, 11(2) Spring 2000. Retrieved September 10, 2000, from <http://scholar.lib.vt.edu/ejournals/JTE/v11n2/williams.jte-v11n2.html>
- Wiske, M. S. (1994). How teaching for understanding changes the rules in the classroom. *Educational Leadership*, 51(5), 19-21.
- Young-Hawkins, L. V., & Mouzes, M. (1991). *Transforming facilities: Industrial arts to technology education*. Paper presented at the American Vocational Association Convention, Los Angeles, CA, December 7, 1991. (ERIC Document Reproduction Service No. ED 341 868).